

MOSQUITO STUDIES (Diptera, Culicidae)

I. A PROJECT FOR A SYSTEMATIC STUDY OF
THE MOSQUITOES OF MIDDLE AMERICA¹

By

John N. Belkin², Robert X. Schick², Pedro Galindo³
and Thomas H. G. Aitken⁴

¹ This investigation is supported in part by Public Health Service Research Grant AI-04379, from the National Institute of Allergy and Infectious Diseases; and in part by U. S. Army Medical Research and Development Command, Department of the Army, under Research Contract DA-49-193-MD-2478.

² Department of Zoology, University of California, Los Angeles, California 90024.

³ Gorgas Memorial Laboratory, Apartado 6991, Panama, Republica de Panama.

⁴ Trinidad Regional Virus Laboratory, P. O. Box 164, Port of Spain, Trinidad.

INTRODUCTION

Definition of Area. Middle America, as here defined, comprises Central America and the West Indies as well as adjacent portions of North America and South America and their islands, within the following arbitrary boundaries: in the north the 35° parallel and in the south the northern margin of the Amazon basin westward across the Andes to Punta Parinas in northern Peru (fig. 1). The region thus defined comprises the following political divisions: United States (Southwestern, Southern and Southeastern States), Mexico (including Guadelupe and Revillagigedo islands), British Honduras, Guatemala, Honduras, El Salvador, Nicaragua, Clipperton Island, Costa Rica (including Cocos Island), Panama, Colombia (all except southeastern part), Ecuador (western part and Galapagos Islands), Peru (extreme northwestern tip), French Guiana, Surinam, British Guiana, Venezuela, Trinidad and Tobago, British West Indies and other dependencies, Netherlands West Indies, French West Indies, Virgin Islands, Puerto Rico, Dominican Republic, Haiti, Jamaica, Cuba, Bahama Islands and Bermuda.

Current Status of Knowledge. The mosquito fauna of Middle America has not been studied as a unit since the monumental monograph "The Mosquitoes of North and Central America and the West Indies" by Howard, Dyar and Knab (1912-1917) which was based on field work carried out primarily from 1905 through 1908, at the time of the building of the Panama Canal, and the revision and supplement to this monograph, "The Mosquitoes of the Americas," by Dyar (1928). In spite of the vast amount of material and information that has accumulated in nearly 50 years, little progress has been made in understanding or adequately describing this mosquito fauna since the appearance of the first publication mentioned above. Lane's "Neotropical Culicidae" (1953), the latest general work covering the area, is inadequate because of incomplete coverage, superficial treatment of species and unreliable keys and illustrations. At the present, one has to rely for identification in many groups on Dyar (1928) or even Howard, Dyar and Knab (1915, 1917). While many new species have been described and several regional lists and studies have been made (notably Anduze 1947; Bonne and Bonne-Wepster 1925; Carpenter and LaCasse 1955; Cova-Garcia 1961; Fauran 1961; Hill and Hill 1948; Komp 1936; Kumm, Komp and Ruiz 1940; Kumm and Zuniga 1942; van der Kuyp 1954; Martini 1935; Patino-Camargo 1940; Perez Vigueras 1956; Tulloch 1937; Vargas 1956, 1959; Vargas and Martinez Palacios 1956), only a few groups have been studied in some detail for the entire area (notably Belkin and Hogue 1959; Foote 1954; Forattini 1961; Galindo, Blanton and Peyton 1954; Komp 1942; Rozeboom and Komp 1950; Simmons and Aitken 1942). The immature stages of many species are not known at present and in many groups species are differentiated primarily or entirely on male genitalia. In several groups it is impossible to get accurate identification even of common species. In many instances very distinct species have been erroneously synonymized with widespread species on very superficial characters. No attempt has been made to analyze the mosquito fauna of the entire area, very little attention has been paid to the study of nonbiting forms and only a few species have been completely described in all stages.

In recent years a great deal of new material and information have been obtained in several localities in this area in connection with studies on mosquito-borne diseases. The material has been studied only as pressure of other work

has permitted and the data obtained have not been summarized or systematically analyzed. At the present time extensive projects on malaria eradication are in operation in this area, much other mosquito control work is being carried on and extensive studies on insect-borne viruses are in progress. This is a most propitious time to carry out a systematic project on the mosquito fauna of the entire area because there is a great need for a more detailed and more readily available knowledge of the taxonomy, distribution and bionomics of vector species and because of the willingness, even eagerness, of many workers to contribute to the project through collections, rearings, observations and detailed studies.

Significance of Project. This project should contribute materially to a better understanding of the mosquito fauna of Middle America. From a practical standpoint this may be of considerable importance in the control of mosquito-borne diseases in the area. It would also be of considerable value for the epidemiological studies on mosquito-borne viruses currently being carried out in Middle America. The cooperative studies and the training of students from Middle America may be of significance in providing a stimulus for independent studies of this type in the future.

In addition to the strictly utilitarian aspects, the mosquito fauna of Middle America is of extraordinary interest to the biologist because it is the most unique and precinctive (endemic) one in the world. In this area all the "neotropical" phylads (natural groups) are represented and several of these are completely precinctive to Middle America. There are also several annectant precinctive "nearctic" phylads in this area. Although many biogeographers regard Middle America, and particularly Mexico and Central America, as a transitional zone between the Nearctic and Neotropical regions, there are indications that at least in the case of mosquitoes this area has been the main center of origin and distribution of the precinctive phylads of the New World (Belkin 1961: 164, 1962: 57-59). On a worldwide basis only the intercontinental Indo-Pacific area has been of greater importance in the evolution of mosquitoes. It is also evident that in Middle America there are many relict species and that their present distributions may be of considerable value in reconstructing the geological history and understanding the biogeography of the New World. A more thorough knowledge of this mosquito fauna in all its aspects will undoubtedly contribute materially to a better understanding of the morphology, ecology and evolution of mosquitoes.

History and Future Development of Project. Belkin became interested in this area following the collection of several Arizona and California mosquitoes which exhibited affinities with Mexican and Central American forms (Belkin and McDonald 1955, 1956, 1957; McDonald 1957a, 1957b; McDonald and Belkin 1961). After a study of the crabhole mosquitoes of the genus Deinocerites (Belkin and Hogue 1959) it was decided to organize a project on the "Mosquitoes of Middle America" and to seek support from the U.S. Public Health Service. The project began in January 1962 under Research Grant AI-04379 and received additional support in August 1963 from U.S. Army Medical Research and Development Command. Charles L. Hogue was Co-investigator from the beginning to June 30, 1964 and Robert X. Schick, who joined the project in November 1963, became Co-investigator on July 1, 1964.

From its beginning the project received enthusiastic support from a large number of individuals and organizations in Middle America. The purpose of

the present article is to describe the scope, objectives, organization and methodology of the project "Mosquitoes of Middle America" and to bring this project to the attention of all individuals and institutions interested in the mosquitoes of the area. It is anticipated that this long-term project will be carried on for 10 to 15 years and can only be accomplished successfully with the cooperation of workers from all the countries of the area. We wish to point out also that several facilities and services are now or soon will be available for interested parties in our main laboratory at the University of California, Los Angeles (UCLA).

OBJECTIVES AND SCOPE

The primary objectives of the project are: (1) to describe and illustrate in detail all the known stages of mosquitoes found in the area, (2) to summarize all the readily available information on distribution, bionomics and disease relations of all species, (3) to analyze the mosquito fauna of the area from the standpoint of its composition, origin and evolution and its relationships with the mosquito fauna of the rest of the world and (4) to make all the data obtained available in preliminary and definitive publications.

The entire family Culicidae in the broadest sense, including the subfamilies Culicinae (true mosquitoes), Dixinae (dixa midges) and Chaoborinae (phantom midges), will be studied. The magnitude and complexity of the project can be appreciated from the fact that at the present time about 600 species have been reported from the area as defined in the INTRODUCTION (Stone, Knight and Starcke 1959; Stone 1961, 1963) and it is evident that there are many undescribed and many incorrectly synonymized species. Many of the indigenous forms have been identified as wide-ranging species, originally described from outside the area, on the basis of very hasty comparison and incomplete knowledge of immature stages. A total of 1420 described nominal forms will have to be considered in this study. It seems likely that eventually there will be recognized well over 1,000 species from the area. It is obvious therefore that only an organized long-term systematic project dealing exclusively with taxonomy in all its phases will enable us to attain a reasonable knowledge of this complex fauna.

ORGANIZATION

Los Angeles Laboratory. Headquarters for the project are located in the Zoology Department, University of California, Los Angeles (UCLA). The professional staff for the project consists at present of John N. Belkin, Project Director and Robert X. Schick, Co-investigator. The technical staff includes 3 full time technicians and several part-time student assistants and illustrators. All the standard equipment necessary for taxonomic work (microscopes, illuminators, mechanical drawing aids, etc.) as well as a rearing room are available. The central research collection of mosquitoes of Middle America is maintained here (see MATERIAL) and there is also a representative collection of mosquitoes of the world, which is particularly strong in Australasian forms. A complete classified file of literature on mosquitoes of Middle America is being formed (see DOCUMENTATION) and will be available to all inter-

ested parties. The laboratory processes and prepares for study all the material and maintains records of all the data obtained for the project. It also maintains stocks of supplies and equipment used in the field. The bulk of the taxonomic studies will be carried on here by the UCLA staff independently or jointly with cooperators. All the facilities and services of the laboratory are freely available to cooperators, including identification of material, illustration and preparation of manuscripts for photo-offset publication. Members of the UCLA staff will also carry on special field studies as well as surveys in areas where cooperators are not available and will take part in training technicians for cooperative field projects.

Cooperators. Although originally designed as a personal research project, the program on the "Mosquitoes of Middle America" is now an informal cooperative effort of many individuals and organizations in the area as indicated in the ACKNOWLEDGMENTS. Its magnitude and usefulness are dependent to a large extent on the efforts of individual cooperators. To date much of the material for study has been obtained through voluntary cooperators. It is planned for the bulk of the field work in the future to be done by local personnel under the supervision of senior cooperators with the assistance, when needed and desired, of UCLA in the matter of coordination, instructions, training, supplies and equipment (see FIELD WORK). Other ways in which cooperators can contribute to the project is by making available previously collected material and data (including reprints of all papers), providing field facilities for the UCLA staff, and by undertaking joint or independent studies of the local fauna. Joint taxonomic studies by senior professional personnel from Middle America and the UCLA staff are being developed and it is planned to bring a number of these investigators for short periods to Los Angeles to work on special problems. Eventually we hope to have at least one cooperator in each country with whom joint studies will be undertaken on the local fauna or on special groups. As indicated above, the Los Angeles laboratory will provide a number of facilities for cooperators not only for joint projects but for independent studies on the mosquitoes of the area as well. The disposition of the material obtained for the project is discussed in the section on MATERIAL and the arrangements for authorship of articles arising from joint studies in the section on PUBLICATIONS. The financing of cooperative or joint studies is indicated below.

Students. An important feature of the project is the training of investigators to carry on and extend the present studies. Qualified students will be given the opportunity to pursue graduate studies in the Zoology Department, University of California, Los Angeles while employed as part-time Research Assistants on the project. In addition to the routine taxonomic work for their employment the majority of these students will be undertaking a research problem directly related to the project. It is hoped that in this manner we will arouse the interest and will train young nationals from Middle America as well as the United States to carry on additional studies independently in the future.

Financing. The project is currently supported primarily by research funds supplied by the U.S. Public Health Service and the U.S. Army Medical Research and Development Command and administered by the University of California, Los Angeles (see footnote on page 1). The facilities in Los Angeles are provided by the University of California. Limited funds are available from the grants for the purchase of services for the collection of mosquitoes from cooperating individuals, organizations or institutions. In general these funds

can be used for all expenses incurred in connection with the collection, rearing and shipment of material expressly gathered for the project. All supplies and equipment for the field work are also provided by UCLA. However, it is not practical to buy vehicles or to hire full time personnel with the available research funds. Therefore, the cooperating agencies are expected to provide these but will be reimbursed for the extra expenses through the project when needed. It is hoped that at least some cooperating organizations will see fit to include this project as part of their regular activities and will provide funds for their phase of the work through their regular budget. For disposition of material obtained through cooperatively financed field work see the section on MATERIAL.

Research funds will also be available to bring senior cooperators for short periods to the Los Angeles laboratory for special joint or individual taxonomic studies and will provide qualified young nationals from Middle America with an opportunity to finance graduate studies at the University of California, Los Angeles through half time employment as Research Assistants on the project. All publications connected with the project will also be financed through the research funds.

MATERIAL

Nature and Source. It is planned to study all the mosquito material from Middle America, whatever its type and condition, now preserved in various museums, institutions or private collections and to make special collections and rearings at several strategic localities (see FIELD WORK). All the material specifically collected for or donated to the project will be processed, prepared, labeled and stored according to standardized methods at UCLA and will remain there for the duration of the project as the Research Collection (see below). Other material will be borrowed from or studied at various museums and institutions.

Labeling. Collections made for the project will carry a distinctive printed general country locality label with one or more letter codes for the country and a single consecutive numerical sequence beginning with #1 for all collections for each letter code (fig. 2). All the data pertaining to each collection, including the exact locality, will be entered on a standard record card (see FIELD WORK and Belkin et al. 1965) and the data from these cards will be summarized and published periodically (see PUBLICATIONS). Every specimen identified on the project will be provided with a distinctive species label (fig. 2), attached to the pin or slide or included in the vial. The date of identification (last two digits of year) and male sex sign will be written in (the specimen is a female if this is missing).

Processing. For the sake of uniformity and to conserve time no permanent mounts of adults or immatures should be made in the field. The material will be preserved, packed and shipped according to the methods outlined by Belkin et al. (1965). At UCLA standardized techniques will be used for all the material, in general following the methods of Belkin (1962: 68-71, 73-77). The adults will be mounted on the right side, legs facing the pin, on heavy paper "points," using "Ambroid" cement. All the mounts on slides will be in clear "Euparal" and with #1 thickness circular coverglasses.

Disposition of Types. Holotypes, allotypes and paratypes of new mosquito species described on the project will be deposited as follows:

(1) When the holotypes and allotypes are specimens collected for the project they will be deposited in the U.S. National Museum (USNM).

(2) When the holotypes, allotypes and/or paratypes are specimens borrowed from institutions or individuals the depository of these will be determined in consultation with the owner(s) of the specimens.

(3) Paratypes of all new species, as far as their number will permit, will be deposited in the following institutions: UCLA; USNM; British Museum (Nat. Hist.) (BMNH); Gorgas Memorial Laboratory, Panama; Faculdade de Medicina de Universidade de Sao Paulo, Brazil; Museo de la Plata, Argentina.

(4) Paratypes of species described from a particular country or dependency will be deposited also in an appropriate national scientific or research institution in their country of origin or mother country as follows:

COLOMBIA, Instituto Nacional de Salud Publica

COMMONWEALTH NATIONS and BRITISH DEPENDENCIES, Trinidad Regional Virus Laboratory or Institute of Jamaica

COSTA RICA, Universidad de Costa Rica

FRENCH DEPENDENCIES, Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM), Bondy, France

GUATEMALA, Entomoteca de Sanidad Publica

MEXICO, Instituto de Salubridad y Enfermedades Tropicales

NETHERLANDS DEPENDENCIES, Instituut voor Tropische Hygiene, Amsterdam

PANAMA, Gorgas Memorial Laboratory

PUERTO RICO and the VIRGIN ISLANDS, School of Tropical Medicine, University of Puerto Rico

VENEZUELA, Instituto de Higiene

For other countries type depositories will be designated later.

Research Collection. The bulk of the material collected for or donated to the project will constitute the Research Collection which will remain in the Department of Zoology, University of California, Los Angeles for the duration of the project and will be available for study to any qualified investigator on request. Upon completion of the project it will be deposited in toto at the U.S. National Museum if facilities are available or if these are limited then at the Los Angeles County Museum.

Regional Reference Collections. A representative collection of the species occurring in each country will be deposited in the institutions mentioned above as depositories of paratypes. Representative collections of species occurring in the entire area will be deposited at USNM, BMNH and any of the above-mentioned institutions that may be interested.

Identification Service. The UCLA laboratory will endeavor to provide a service for the identification of mosquitoes of the area starting immediately. Naturally in some groups specific identifications will not be possible for some time. Material forwarded for identification must be prepared and packed according to the methods specified in Belkin et al. (1965). A share of the identified material will be retained at UCLA.

DOCUMENTATION

In a project of this size and complexity it is essential that all the data are readily available for use and comparison. Therefore a special effort will be

made to provide a documentation center for the project at UCLA. All the information will be available on request to qualified investigators.

Literature File. There will be prepared and maintained a complete file of all the literature dealing with the mosquitoes of Middle America in the fields of taxonomy, bionomics, distribution and disease relations. The individual articles will be reproduced by xerography and portions of these copies will also be filed under the appropriate classified files as indicated below. We urgently request all cooperators to send reprints of all papers and reports, particularly those appearing locally, to the UCLA literature file at the earliest opportunity.

Collection File. A standard form (Belkin et al. 1965) will be used to record all the appropriate data for the field collections made for the project. These forms will serve as the basis for compilations on distribution, bionomics and faunal analysis. Xerographic copies of these will also be filed under the respective species, providing distribution records as well as data on bionomics.

Taxonomic File. All data pertaining to a given taxon will be reproduced by xerography (or a similar process) and kept in a file under that taxon. This will include pertinent portions of all published papers dealing with the taxon and unpublished data accumulated during the present investigation, i. e. all the collection and distribution records, illustrations and notes.

Distribution File. For each country or island there will be prepared (1) a file of all species originally described from that locality, (2) a file of all species reported.

FIELD WORK

Scope. A vast amount of mosquito material is available from Middle America but very little of it includes individual or progeny rearings without which definite association of sexes and stages and unequivocal identification as to species cannot be made. Therefore it is essential for the project to obtain this type of material. A complete census of all species occurring in Middle America could not be accomplished in the life time of a single generation of investigators even with continuous systematic collecting throughout the area year after year. For the present project field studies will have to be limited to the most significant features needed to place the study of the mosquitoes of the area on a firm foundation.

Although considerable material from some areas has been accumulated since field work on the project began in November 1962 it will be necessary to carry on more or less extensive field studies for several years in nearly all the countries included in the project. In addition since many of the important species reported from Middle America were originally described from Brazil and Argentina and a few from Bolivia, Chile, Paraguay, Peru and Uruguay it will be essential to obtain reared topotypic material of these forms either through field work in these countries or by exchange with local cooperators.

Personnel. The field work will be done whenever possible by local personnel under the supervision of cooperators after a brief period of training by a member of the UCLA staff. Where cooperators are not available field parties from UCLA will do the collecting and rearing. Each of the Research Assistants will spend at least two months in the field on surveys or on special field problems, preferably from a base at a cooperating institution.

Methods. The collections and rearings will be done according to simple techniques and using standardized equipment and forms that will enable us to obtain a large quantity of uniform material with a minimum of effort (see Belkin et al. 1965). Although emphasis will be on individual and progeny rearings it is very important to obtain general collections of adults and immature stages also. All the material will be processed, mounted and provisionally identified at UCLA.

Topotypic Surveys. Primary emphasis will be given at the beginning to obtaining individual and/or progeny rearings of topotypic material of species described from the area. It will also be necessary to obtain similar material of species described from outside the area but reported from Middle America in order to establish the true identity of the Middle American forms. Since in many instances the type localities have been destroyed or are not accessible it will be necessary to obtain this material from a similar habitat as close as possible to the original type locality. In the course of topotypic surveys, as conditions and resources permit, other species will be collected and reared.

General Surveys. Whenever possible general surveys will be started in each country to sample as many different types of habitats as possible in all the different regions, particularly those not previously surveyed. Any material that can be readily obtained, as in connection with arbovirus studies or malaria eradication projects, would be very valuable for this project.

Special Problems. In connection with taxonomic, dispersal or ecological problems special intensive field work will be undertaken in selected areas. Detailed information on the bionomics and ecological relationships of most groups of mosquitoes in Middle America is lacking. Because of biogeographic significance particular attention will be paid to species occupying certain types of habitats, notably crabholes, treeholes and leaf axils of plants. The specificity of the association of mosquitoes breeding in the leaf axils of certain species of plants is not well documented and will receive special attention also.

RESEARCH PROCEDURES

Personnel. The procedures described here have been developed primarily for the UCLA staff and will be modified as necessary for special cooperative studies. It is hoped that cooperators will participate in all the different types of studies outlined below throughout the duration of the project.

Taxonomic Studies. The basic research on the project will consist of taxonomic studies of various types, including the following: (1) preliminary reviews of species groups, subgenera and genera, (2) descriptions of new forms and previously undescribed stages, (3) thorough monographs of important groups and (4) a reexamination of the entire fauna in connection with the final book form publication.

The preliminary reviews will be based primarily on identified material borrowed from major museums and whatever new reared topotypic material is available early in the project. These reviews will serve as starting points for later monographs and will provide provisional identification keys for use in the field as well as in the laboratory. It is planned to make preliminary reviews of all groups, starting with the most conspicuous and simplest groups. For such reviews at least one species will be completely illustrated in each group. For the descriptions of new forms and stages, complete illustrations will be

made for each stage treated whenever feasible, and these will form the basis for the monographs which will be undertaken only after topotypic material of the majority of species is available.

Taxonomic Procedures. The general taxonomic procedures, terminology and method of presentation will follow the pattern used in Mosquitoes of the South Pacific (Belkin 1962). All taxonomic studies will be based on consideration of all stages: males, females, larvae, pupae, and eggs whenever possible. Slide mounts of whole adults, male and female genitalia will be prepared from a sample of every collection. In addition to slide mounts of associated larval and pupal skins, there will be prepared whole mounts of samples of larvae from every collection.

For every species with associated stages and sexes preliminary drawings will be made for the adults (entire external morphology or pertinent details), and for the larvae and pupae (complete external morphology and complete chaetotaxy for both), from material selected by the professional staff. Using these preliminary drawings Research Assistants will check other material (10 or more specimens) of the presumed same species to record on special forms the range of variation in the expression of all characters figured, in the same population and in other populations. It is likely that at this stage undescribed forms will become apparent. Distinguishing characters will then be selected by the professional staff, and from these, keys will be prepared for all the stages. All the material of a group will then be checked through the keys for the diagnostic characters. It is likely that additional new forms will be found in this process. The verbal description of each stage of a species will then be prepared and significant ecological and geographical variants will be noted by the professional staff.

The final drawings and final descriptions will be made for the topotypic population and will not be a representation of one individual only. Ecological and geographical variant populations will be covered as fully as the material and time will allow. Throughout the taxonomic work emphasis will be placed on presentation of graphic and meristic data. Verbal descriptions will be limited to distinguishing and variable characters not amenable to graphic representation. Attributes shared by species within a group will be given under the description of that group. Keys will be prepared to adults, male genitalia, fourth instar larvae and pupae and, when possible, to eggs and to other larval instars and female genitalia.

In order to establish the identity of previously described species, it will be necessary for the professional staff to study type specimens located in various institutions in the Americas, Europe and North Africa. Material compared with types will be so marked and deposited in the Research Collection at UCLA for further study.

Distribution, Bionomics and Disease Relations. Information on distribution, bionomics and disease relations will be obtained from the literature, from the records of previous collectors and from the standard collection record forms (Belkin et al. 1965) which will be used in all the field work for the project. Special field studies will be undertaken for the elucidation of significant ecological and distributional problems (see FIELD WORK). All these records will be reproduced by xerography and filed under both the individual species and the various countries.

The following special outline maps will be drafted and reproduced for the project: a general map of Middle America, sectional maps of Middle America

on a larger scale, and a map of the Western Hemisphere. The world map prepared by Belkin (1962) will also be used. The entire known range of all species will be plotted on appropriate combinations of these maps. Whenever feasible the distributions of members of a group will be shown together on the same maps.

All the information on distribution, bionomics and disease relations will be summarized on (1) a chart of all the species for the entire area and (2) more detailed charts for each country.

Faunal Analysis. The analysis of the mosquito fauna will be based on a comparison of the taxonomic affinities of the various species (determined primarily on the basis of degree of morphological similarity in all stages) in different parts of Middle America and the distribution of species groups to which these belong in adjacent areas in the Western Hemisphere as well as the world as a whole. Charts will be prepared showing the composition and detailed distribution of the elements of the mosquito fauna (by species complex, species group or higher unit) in the faunal subdivisions comprising the area.

PUBLICATIONS

Scope. Three types of publications will be produced: (1) periodic preliminary papers as the work progresses, (2) more thorough and extensive monographs and (3) a final definitive book of several volumes.

Authors. It is expected that many of the taxonomic papers will be joint contributions of cooperators and UCLA staff members. Co-authorship will be sought for all papers dealing with local mosquito faunas. Seniority in joint authorship will be determined on the basis of actual contributions of respective authors to the particular paper. Investigators are invited to use all the publication facilities (including illustration, composition and editing) for all personal papers dealing with the mosquito fauna of the area.

Illustrations. In all publications emphasis will be placed wherever possible on the use of illustrations of all kinds (drawings, tables, maps) in preference to words. With the method of publication chosen it is more convenient and just as inexpensive to use illustrations as a lengthy text. Facilities for the preparation of final illustrations are available at UCLA to all cooperators. For uniformity and economy reasons illustrations will be standardized and grouped together on full pages for reproduction.

Method. Printing will be done by the photo-offset method. The text copy will be prepared on an IBM Executive typewriter at UCLA under constant supervision and control at the same time that the final illustrations are assembled and labeled. This method of publication is the quickest and least expensive, favors graphic presentation and allows maximum control of accuracy. The actual publication and distribution will be done by the American Entomological Institute through its established serial publications. Financing of publications will be accomplished by a minimal charge per page for the reprints, which will be charged to the project in the case of cooperative studies and to individuals or institutions in the case of independent contributions.

Preliminary Papers. The following types of papers will be published as quickly as they can be prepared: (1) methods and techniques for collection, rearing, preservation and preparation of material, (2) lists of mosquitoes originally described and/or reported from each country, (3) provisional keys

to major groups of mosquitoes, (4) descriptions of new species and undescribed stages, (5) taxonomic notes, synonymies, changes in taxonomic status, etc., (6) preliminary reviews of species groups, subgenera and genera, (7) new locality records, (8) notes on bionomics, (9) collection records for field work in each country and (10) special short studies. The majority of these papers will be published periodically in the series "MOSQUITO STUDIES," edited by Belkin and issued as separate numbers of the Contributions of the American Entomological Institute as in the present instance. Very quick and economical publication can be obtained as soon as at least 64 pages are prepared for printing for an individual issue.

Monographs. Thorough studies on important taxonomic groups, dissertations of Research Assistants working on the project, major faunal studies and extensive special studies of various kinds, if they will print 300 or more pages, will be published as Memoirs of the American Entomological Institute.

Book. Upon completion of the project a book of several volumes covering the mosquito fauna of the entire area will be published. The general plan will follow the treatment in the Mosquitoes of the South Pacific (Belkin 1962). The emphasis in the taxonomic section will be on illustration, tentatively a full page each for (1) the adults and the female genitalia, (2) male genitalia and pupa and (3) the larva.

ACKNOWLEDGMENTS

We are most grateful to the following individuals and organizations for assistance, cooperation and encouragement in carrying out the project to date:

ARGENTINA: Antonio Martinez, San Isidro, Buenos Aires.

BRAZIL: L. Deane and O. Forattini, Universidade de Sao Paulo.

CANAL ZONE: W. P. Murdoch and M. Keenan, Office of the Surgeon, USARCARIB.

CHILE: L. E. Pena G., Santiago.

COLOMBIA: E. Osorno-Mesa, Instituto Nacional de Salud Publica; R. Elliott and G. Ruiz, Servicio Nacional de Erradicacion de la Malaria; C. J. Mankelle, Universidad de Los Andes; P. Barreto-Reyes and V.E. Lee, Universidad del Valle and The Rockefeller Foundation, Cali.

COSTA RICA: G. Havord, Instituto Interamericano de Ciencias Agricolas; F. Granados and G.W. Hunter, International Center for Medical Research and Training, LSU; J. De Abate and M. Vargas, Universidad de Costa Rica.

FRANCE: E. Abonnenc, Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM).

FRENCH GUIANA: H. Floch, Institut Pasteur.

GUADELOUPE: P. Fauran, Institut Pasteur.

GUATEMALA: J. Ibarra, Museo Nacional de Historia Natural; E. Novales and O. Ochoa, Servicio Nacional de Malaria; M. Dary R., Universidad de San Carlos; D. McCorquedale, AID; R. Jenney, Oficina Sanitaria Panamericana; L. M. Drennan, B. J. Diaz, T. A. Holcombe and C.E. Pinto, United Fruit Co.

HONDURAS: A. C. Hamilton and F. Sheehy, Tela Railroad Co.

JAMAICA: A. Goodbody and W. Page, University of the West Indies.

MEXICO: L. Vargas and A. Diaz Najera, Instituto de Salubridad y Enfermedades Tropicales; R. W. Dickerman, Oficina Sanitaria Panamericana.

NICARAGUA: L. Izquierdo, AID; D. Massi, Oficina Sanitaria Panamerica.

NETHERLANDS: P. W. Hummelinck, Foundation for Scientific Research in Surinam and the Netherlands Antilles; J. Bonne-Wepster, Instituut voor Tropische Hygiene en Geographische Pathologie.

PANAMA: P. Galindo V. and A. Quinonez, Gorgas Memorial Laboratory.

PUERTO RICO: I. Fox, School of Tropical Medicine.

TRINIDAD: T. H. G. Aitken and L. Spence, Trinidad Regional Virus Laboratory.

UNITED KINGDOM: P. F. Mattingly, British Museum (Nat. Hist.).

UNITED STATES OF AMERICA: H. K. Townes, American Entomological Institute; E. G. Gerberg, Insect Control and Research, Baltimore, Md.; H. Friedmann, C. L. Hogue and F. S. Truxal, Los Angeles County Museum; R. B. Allen, J. A. Kerr and L. J. da Silva, Pan American Health Organization; S. J. Carpenter, Sonoma, California; A. Stone, U.S. National Museum; F. Iltis and R. O. Schuster, University of California, Davis; B. Bartholomew, G. A. Bartholomew, K. Bartholomew, M. Buchanan, E. Fisher, T. R. Howell, M. Lloyd, M. E. Mathias, S. R. Telford and D. Verity, University of California, Los Angeles; F. S. Blanton, University of Florida; A. Spielman, School of Public Health, Harvard University; L. E. Rozeboom, School of Hygiene and Public Health, Johns Hopkins University; J. K. Jones, University of Kansas; G. F. Edmunds, University of Utah.

VENEZUELA: P. Cova-Garcia, Direccion de Malariologia, Maracay; O. M. Suarez, Instituto Venezolana de Investigaciones Cientificas; I. Ortiz C., Instituto de Higiene.

REFERENCES CITED

Anduze, Pablo J.

1947. Contribución al estudio de los vectores de la fiebra amarilla en Venezuela. Acad. de Cien. Fis. Mat. y Nat., B. 10: 331-373.

Belkin, John N.

1961. Unstable tropical mediterranean areas as sites of origin of major evolutionary changes. Ent. Soc. Amer., B. 7: 164.

1962. The mosquitoes of the South Pacific (Diptera, Culicidae). Berkeley, U. Calif. Press. 2 vol.

Belkin, John N. and C. L. Hogue

1959. A review of the crabhole mosquitoes of the genus Deinocerites (Diptera, Culicidae). Calif. U., P. Ent. 14: 411-458.

Belkin, John N., C. L. Hogue, P. Galindo, T. H. G. Aitken, R. X. Schick and W. A. Powder

1965. Mosquito studies (Diptera, Culicidae) II. Methods for the collection, rearing and preservation of mosquitoes. Amer. Ent. Inst., Contrib. 2: 19-78.

Belkin, John N. and W. A. McDonald

1955. A population of Corethrella laneana from Death Valley, with descriptions of all stages and discussion of the Corethrellini (Diptera, Culicidae). South. Calif. Acad. Sci., B. 54: 82-96.

1956. A population of Uranotaenia anhydor from Death Valley, with a description of all stages and a discussion of the complex (Diptera, Culicidae). Ent. Soc. Amer., Ann. 49: 105-132.

1957. A new species of Aedes (Ochlerotatus) from treeholes in southern Arizona and a discussion of the varipalpus complex (Diptera, Culicidae). Ent. Soc. Amer., Ann. 50: 179-191.
- Bonne, C. and J. Bonne-Wepster
1925. Mosquitoes of Surinam. . . Roy. Colon. Inst. Amsterdam, Meded. 21. 558 p. (Afd. Trop. Hyg. 13).
- Carpenter, Stanley J. and W. J. LaCasse
1955. Mosquitoes of North America (North of Mexico). Berkeley, U. Calif. Press. 360 p.
- Cova-Garcia, Pablo
1961. Notas sobre los anofelinos de Venezuela y su identificacion. Ed. 2. Caracas, Editora Grafos. 212 p.
- Dyar, Harrison G.
1928. The mosquitoes of the Americas. Washington, Carnegie Inst. (P. 387). 616 p.
- Fauran, Pierre
1961. Catalogue annoté des Culicidés signalés en Guyane Francaise. Inst. Pasteur de la Guyane Franc. et de l'Inini (Arch. 22) P. 465. 60 p.
- Foote, Richard H.
1954. The larvae and pupae of the mosquitoes belonging to the Culex subgenera Melanoconion and Mochlostyrax. U. S. Dept. Agr., Tech. B. 1091. 126 p.
- Forattini, Oswaldo P.
1961. Chaves para identificacao de genero Anopheles Meigen, 1818, da Regiao Neotropical (Diptera, Culicidae). Rev. Bras. de Ent. 10: 169-187.
1962. Entomologia Medica. Sao Paulo, Facul. de Higiene e Saude Publica. 662 p.
- Galindo, Pedro, F. S. Blanton and E. L. Peyton
1954. A revision of the Uranotaenia of Panama with notes on other American species of the genus (Diptera, Culicidae). Ent. Soc. Amer., Ann. 47: 107-177.
- Hill, Rolla B. and C. McD. Hill
1948. The mosquitoes of Jamaica. Inst. Jamaica, B. (Sci. Ser.) 4. 60 p.
- Howard, Leland O., H. G. Dyar and F. Knab
1912-1917. The mosquitoes of North and Central America and the West Indies. Washington, Carnegie Inst. (P. 159). 4 vol. Vol. 1 (1913); Vol. 2 (1913); Vol. 3, 1915; Vol. 4, 1917.
- Komp, William H. W.
1936. An annotated list of the mosquitoes found in the vicinity of an endemic focus of yellow fever in the Republic of Colombia. Ent. Soc. Wash., Proc. 38: 57-70.
1942. The anopheline mosquitoes of the Caribbean Region. Nat. Inst. Health, B. 179. 194 p.
- Kumm, Henry W., W. H. W. Komp and H. Ruiz
1940. The mosquitoes of Costa Rica. Amer. J. Trop. Med. 20: 385-422.
- Kumm, H. W. and H. Zúñiga
1942. The mosquitoes of Salvador. Amer. J. Trop. Med. 22: 399-415.
- van der Kuyp, Edwin
1954. Mosquitoes of the Netherlands Antilles and their hygienic importance. Studies Fauna Curaçao Caribbean Islands 5: 37-114.

Lane, John

1953. Neotropical Culicidae. Sao Paulo, Univ. Sao Paulo. 2 vol.

McDonald, William A.

1957a. The adults and immature stages of Aedes mulleri Dyar (Diptera: Culicidae). Ent. Soc. Amer., Ann. 50: 505-511.

1957b. The adults and immature stages of Aedes purpureipes Aitken (Diptera: Culicidae). Ent. Soc. Amer., Ann. 50: 529-535.

McDonald, William A. and J. N. Belkin

1961. Orthopodomyia kummi new to the United States (Diptera, Culicidae). Ent. Soc. Wash., Proc. 62: 249-250.

Martini, Eric C. W.

1935. Los mosquitos de Mexico. Mexico, Dept. de Salubr. Publica. 65 p.

Patino-Camargo, L.

1940. Artropodos hematofagos de la fauna colombiana. Acad. Colombiana de Cien. Exact. Fis. y Nat., Rev. 3: 337-344.

Perez Vigueras, I.

1956. Los Ixodidos y Culicidos de Cuba, su historia natural y medica. Havana. 579 p.

Rozeboom, Lloyd E. and W. H. W. Komp

1950. A review of the species of Culex of the subgenus Melanoconion (Diptera, Culicidae). Ent. Soc. Amer., Ann. 43: 75-114.

Simmons, James S. and T. H. G. Aitken

1942. The anopheline mosquitoes of the northern half of the Western Hemisphere and of the Philippine Islands (Distribution, habits, identification, importance as vectors, and control). Army Med. B. 59. 213 p.

Stone, Alan

1961. A synoptic catalog of the mosquitoes of the world, Supplement I. (Diptera, Culicidae). Ent. Soc. Wash., Proc. 63: 29-52.

1963. A synoptic catalog of the mosquitoes of the world, Supplement II. (Diptera, Culicidae). Ent. Soc. Wash., Proc. 65: 117-140.

Stone, Alan, K. L. Knight and H. Starcke

1959. A synoptic catalog of the mosquitoes of the world (Diptera, Culicidae). Washington, Ent. Soc. Amer. (Thomas Say Found. P. 6). 358 p.

Tulloch, George S.

1937. The mosquitoes of Puerto Rico. Puerto Rico, U., J. Agr. 21: 137-167.

Vargas, Luis

1956. Especies y distribucion de mosquitos Mexicanos no anofelinos (Insecta Diptera). Inst. de Salubr. y Enferm. Trop., Rev. 16: 19-36.

1959. Lista de Anopheles de las Americas y su identificacion por caracteres masculinos (Diptera: Culicidae). Inst. Salubr. y Enferm. Trop., Rev. 19: 367-386.

Vargas, Luis and A. Martinez Palacios

1956. Anofelinos mexicanos. Taxonomia y Distribucion. Mexico, Sec. de Salubr. y Asistencia. 181 p.

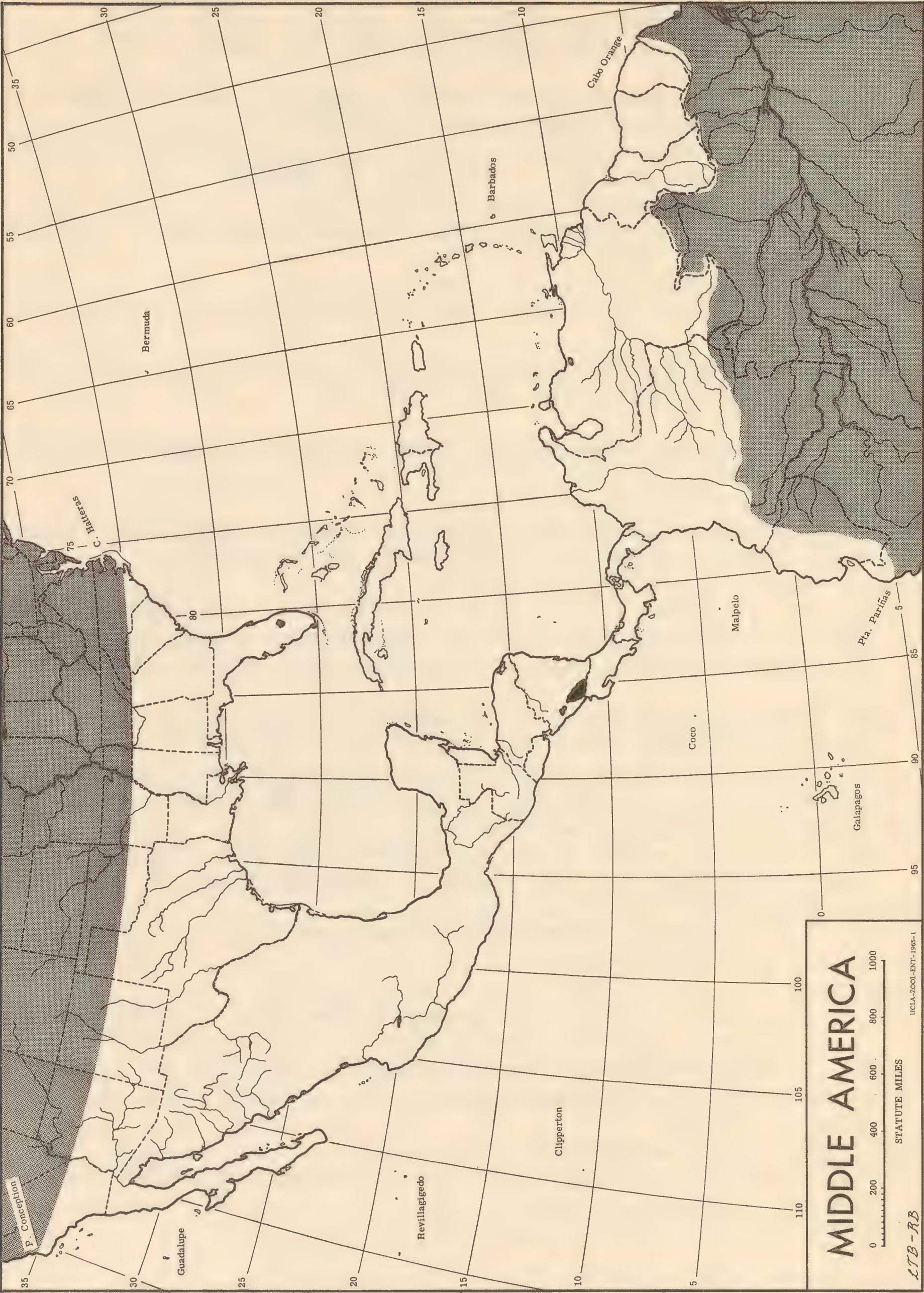


Fig. 1. Map of Middle America

LOCALITY LABELS

| | | | | |
|--|---|--|--|---|
| ARG Argentina 65-66 Mosq Mid Amer | CR Costa Rica 1964 Charles L. Hogue | GG Panama '58 Gorgas M Lab | LU St Lucia 64-65 Mosq Mid Amer | PER Peru 65-66 Mosq Mid Amer |
| BAH Bahamas 65-66 Mosq Mid Amer | CRR Costa Rica LE Rozeboom leg | GR Grenada 1963 T. H. G. Aitken | MEX Mexico 64-65 Mosq Mid Amer | PR Puerto Rico 64-65 Mosq Mid Amer |
| BAR Barbados 65-66 Mosq Mid Amer | CUB Cuba Mosq Mid Amer | GRR Grenada LE Rozeboom leg | MF Mexico 63/64 Eric M. Fisher | RDO DominicanRep 66 Mosq Mid Amer |
| BG British Guiana 65 Mosq Mid Amer | CV Villavicencio, Col Rozeboom 47-48 | GUA Guatemala 64-65 Mosq Mid Amer | MT Mexico 1963 S. R. Telford | ROZ LE Rozeboom leg |
| BGR British Guiana LE Rozeboom leg | CZ Canal Zone 63/64 W.P.Murdoch, leg | HAC Haiti (Cook) LE Rozeboom leg | MX Mexico | SAL El Salvador 64-65 Mosq Mid Amer |
| BH Br Honduras 65-66 Mosq Mid Amer | DOM Dominica 65-66 Mosq Mid Amer | HAR Haiti LE Rozeboom leg | NI Nicaragua 1964 Gorgas Mem Lab | SUR Surinam 65-66 Mosq Mid Amer |
| BOL Bolivia 64-66 Mosq Mid Amer | ECU Ecuador 65-66 Mosq Mid Amer | HAT Haiti 65-66 Mosq Mid Amer | NIR Nicaragua LE Rozeboom leg | TOB Tobago 65 Mosq Mid Amer |
| BRA Brasil 65-66 Mosq Mid Amer | FG Fr Guiana 65-66 Mosq Mid Amer | HON Honduras 64-65 Mosq Mid Amer | NWI Neth West Indies 65 Mosq Mid Amer | TR Trinidad 63/64 T. H. G. Aitken |
| BRR Brasil LE Rozeboom leg | FGA French Guiana E Abonnenc leg | JA Jamaica 64/65 William A. Page | PA Panama '63 Gorgas M Lab | TRR Trinidad 1941 L. E. Rozeboom |
| CH Chile 64-65 Mosq Mid Amer | FWI Fr West Indies 65 Mosq Mid Amer | KO W. H. W. Komp | PA Panama 63/64 Gorgas Mem Lab | VI Virgin Islands 65 Mosq Mid Amer |
| COB Colombia 64-65 INSP, Bogota, OM | GAL Galapagos 64-65 Mosq Mid Amer | LAR Lesser Antilles 29 LE Rozeboom leg | PAR Panama/CanZone Rozeboom 34-37 | VT St. Vincent 1963 T. H. G. Aitken |
| COE Colombia 64-65 SEM, MSP, Elliott | GG Panama '58 Gorgas Mem Lab | LEE Leeward I 64-65 Mosq Mid Amer | PC Panama/CanZone S. J. Carpenter | VZ Venezuela 65-66 Mosq Mid Amer |
| COL Colombia 64-65 Univ Valle Cali | No. (CR) Costa Rica XI, 7-XII, 11, 62 Hogue & Powder | Panama leg. Carpenter | Panama, Army School Malar. R H Arnett Lot | VZR Venezuela 64-65 LE Rozeboom leg |

IDENTIFICATION LABELS

| | | | | |
|---|--|--|---|--|
| equinus Theobald 65 MosqMidAmer ♂ | albonotatus Coquillett 65 MosqMidAmer o | andinus Levi-Castillo 65 MosqMidAmer ♂ | chidesteri Dyar 65 MosqMidAmer o | cancer Theobald 65 MosqMidAmer ♂ |
| panarchys Dyar 65 MosqMidAmer o | allotecnon K, K & Ruiz 65 MosqMidAmer ♂ | asulleptus Theobald 65 MosqMidAmer o | corniger Theobald 65 MosqMidAmer ♂ | mcdonaldi 65 Belkin & Hogue MosqMidAmer o |
| soperi Levi-Castillo 65 MosqMidAmer ♂ | arborealis 65 Bon-We & Bonne MosqMidAmer o | durhamii Theobald 65 MosqMidAmer ♂ | coronator Dyar & Knab 65 MosqMidAmer o | melanophylum Dyar & Knab 65 MosqMidAmer ♂ |
| tropicalis Cerq & Ant 65 MosqMidAmer o | argyrites 65 Dyar & Nun Tov MosqMidAmer ♂ | flavisetosus Castro 65 MosqMidAmer o | declarator Dyar & Knab 65 MosqMidAmer ♂ | annulipalpis 65 Lynch Arribalz UCLA-ZOOL o |
| albomaculatus Theobald 65 MosqMidAmer ♂ | aurivittatus Cerqueira 65 MosqMidAmer o | guayasi Levi-Castillo 65 MosqMidAmer ♂ | delys H D & K 65 MosqMidAmer o | apicimacula Dyar & Knab 65 UCLA-ZOOL ♂ |

Fig. 2. Locality and Identification Labels